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Effect of the Oils of Lemon and Camphor and of Turpentine on the Germination of Seeds

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EFFECT OF THE OILS OF LEMON AND CAMPHOR AND OF TURPENTINE ON THE GERMINATION OF SEEDS

BY

LELIA MAE ORMSBY

THESIS

FOR THE

DEGREE OF BACHELOR OF ARTS

IN SCIENCE

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

LELIA MAE ORMSBY

ENTITLED EFFECT OF THE OILS OF LEMON AND CAMPHOR AND OF TURPENTINE ON THE GERMINATION OF SEEDS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF BACHELOR OF ARTS

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CONTENTS

Page

I. Introduction. . . . . 1.

II. Radish Seeds. 1. Treated with Oil of Lemon. . 2.

III. Radish Seeds. 2. Seed Coats Ruptured and treated with Oil of Lemon . . . . 4.

IV. Radish Seeds. 3. Treated with Oil of Origanum . 5.

V. Oats Treated with Oil of Lemon. 1. Not Hulled . 6.

VI. Oats Treated with Oil of Lemon. 2. Hulled. . . 7.

VII. Corn. 1. Treated with Turpentine . . . . . 9.

VIII. Corn. 2. Soaked in Water and Treated with Turpentine 10.

IX. Corn. 3. Treated with Camphor . . . . . . 12.

X. Corn. 4. Soaked in Water and Treated with Camphor . 13.

XI. Corn. 5. Treated with Turpentine and Germinated in Soil . . . . 14.

XII. Corn. 6. Treated with Camphor and Germinated in Soil 15.

The Effect of the Oils of Lemon and Camphor and of Turpentine on the Germination of Seeds.

Professor Forbes' experiments on the use of a number of oils as repellents for the root-aphis, show that some of the agents he used had, under certain conditions, a very harmful effect on the germination of seeds. This was particularly true of turpentine, carbolic acid and formalin. It was my object to experiment further along the line of injury done to the seed by oil of lemon and camphor, and of turpentine.

In a number of preliminary experiments, two kinds of seeds, oats and radish were used, and the action of the oils of lemon, origanum and camphor and rectified spirits of turpentine were tried.

Seeds of the radish (Dreer's Icicle) were immersed in oil of lemon for periods ranging from ten minutes to forty-eight hours. Placed under favorable conditions for germination it was found that there was practically no decrease in the number of seeds to germinate.

While the percent of germination was not materially decreased by this immersion, it was found that seeds after more than sixty minutes immersion germinated more slowly, and that the time for germination increased with the period of immersion. As the time for germination increased, fungi became more and more troublesome.

The following table shows the results of the first set of experiments:

Table I.

Radish Seed treated with Oil of Lemon.

Date	Time in Lemon Oil	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 1	10 Min.	2 days	24	25	24	96
Oct. 1	20 "	2 "	22	25	22	88
Oct. 1	30 "	1 "	1			
		2 "	21	25	22	88
Oct. 1	40 "	2 "	22	25	22	88
Oct. 3	50 "	1 "	1			
		2 "	21			
		3 "	1	25	23	92
Oct. 3	1 hr.	1 "	1			
		2 "	15			
		3 "	4			
		4 "	1			
		5 "	1			
		9 "	1	25	23	92
Oct. 3	1 hr. & 10 min.	2 "	23			
		3 "	2	25	25	100
Oct. 3	1 hr. & 20 min.	2 "	20			
		3 "	4	25	24	96
Oct. 3	2 hrs.	1 "	3			
		2 "	18			
		3 "	2			
		4 "	1	25	24	96
Oct. 7	3 hrs.	1 "	1			
		2 "	13			
		3 "	7			
		4 "	2			
		14 "	1	25	24	96
Oct. 8	4 hrs.	2 "	18			
		3 "	3			
		4 "	3	25	24	96
Oct. 9	5 hrs.	2 "	23			
		3 "	1			
		5 "	1	25	25	100

Table I. - continued.

Date	Time in Lemon Oil	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 9	7½ hrs.	2 days	20			
		3 "	2			
		4 "	1			
		8 "	1	25	24	96
" 9	24 "	2 "	1			
		3 "	21			
		4 "	2	25	24	96
" 10	48 "	3 "	20			
		4 "	2			
		5 "	1			
		9 "	1	25	24	96

In order to determine the role if any, of the rather heavy seed coats of the radish in preventing penetration of the oil, a series of experiments was undertaken in which the seed coats were ruptured. The method employed was to puncture the coats with a pin, care being taken not to injure the embryo. The result was that 80% of the total number of seeds germinated. However, as the length of time of immersion in the oil increased, the time required for germination also increased, and at a rate greater than that given in the previous set of experiments, that is seeds with seed coats intact. (Table II.)

The number of seeds attacked by the fungi increased, but germination often took place in spite of the fungi.

Table II.

Radish with Coats ruptured and treated with Oil of Lemon.

Date	Time in Lemon Oil	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct.14	2 hrs.	2 days	16			
		3 "	1			
		4 "	2			
		6 "	2			
		7 "	1			
		20 "	1			
		22 "	1	25	24	96
" 15	3½ "	2 "	17			
		3 "	7	25	24	96
" 10	4½ "	2 "	11			
		3 "	5			
		4 "	3			
		7 "	2			
		9 "	1			
		11 "	1	25	23	92
" 14	24 "	3 "	16			
		4 "	3			
		5 "	2			
		9 "	2			
		10 "	1	25	24	96
" 16	48 "	5 "	8	25	8	32

It was found that although the seeds germinated, the seedlings were abnormal in that the radicals which protruded first in the normal seeds failed to develop. The stem, that is the cotyledons, appeared first and seemingly grew normally. The question then arose as to whether this abnormal growth of the radicle was due to the chemical action of the oil or to mechanical injury done by puncturing the coats. To determine this, punctured seeds, treated with the oils and punctured seeds soaked in water and not treated with the oils were placed under the same favorable conditions for germina-

tion. The injury was apparent in both instances, and consequently the abnormal growth is to be attributed to the injury done in puncturing the seed ooats rather than to the effect of the oil.

Oil of origanum was next tried on the radish seed and with much more fatal results than was found in the case of seeds treated with oil of lemon.

The number to germinate was decreased and the time for germination was much increased. (Table III.)

Table III.

Radish Seed treated with Oil of Origanum.

Date	Time in Origanum	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 27	2 hrs.	2 days	2			
		3 "	6			
		4 "	1			
		5 "	1	25	10	40
" 28	3 "	2 "	1			
		3 "	6			
		7 "	3			
		8 "	1	25	11	44
" 29	4 "	2 "	1			
		3 "	6			
		4 "	1			
		6 "	1			
		8 "	1	25	10	40
" 30	5 "	2 "	2			
		3 "	5			
		4 "	2			
		9 "	1	25	10	40
" 31	6 "	3 "	7			
		6 "	2	25	9	36

Table 111. - Continued.

Date	Time in Orig-anum	Time required for Germina-tion		No. of Seeds	Total No. to Germ.	Percent to Germ.
Nov. 3	24 Hrs.	2 days	1			
		3 "	4			
		4 "	3	25	8	32
" 4	48 "	3 "	3	25	3	12

In order to determine whether or not oil of lemon has the same effect on other seeds as on the radish, oats were treated with the oil of lemon in the same way the radish had been. It was found, however, that they did not germinate in so large a percent as the radish and that the delay in germination was more marked. There is probably some relation between the slowness of the germination of the normal seed and injury due to immersion in the oils. In order to determine whether or not the hull of the oat was responsible for the injuries or delayed germination, it was removed before treatment. It was found (Table V.) that germination was not delayed so long in the case of the hulled oats, and that the number to germinate was larger. Tables 1V. and V. give the results of the treatment with oil of lemon, of oats not hulled and hulled respectively.

Table 1V.

Oats not hulled, and treated with Oil of Lemon.

Date	Time in Oil of Lemon	Time required for Germina-tion		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 9	Normal	3 days	22			
		4 "	1			
		8 "	1			
		9 "	1	25	25	100

Table lV. Continued.

Date	Time in Oil of Lemon	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 14	2 hrs.	6 days	2			
		7 "	3			
		9 "	2			
		10 "	3			
		14 "	1			
		20 "	1	25	12	48
Oct. 13	3 hrs. & 30 min.	7 "	2			
		8 "	4			
		9 "	4			
		10 "	1			
		11 "	1			
		13 "	2			
		14 "	2	25	16	64
" 10	4 hrs.& 30 min.	5 "	1			
		6 "	1			
		8 "	2			
		10 "	3			
		11 "	1			
		12 "	3			
		13 "	1	25	12	48
" 15	6 hrs.	5 "	2			
		7 "	2			
		8 "	1			
		10 "	3			
		14 "	1			
		20 "	1	25	10	40
" 15	24 "	7 "	1			
		9 "	2			
		10 "	1			
		12 "	1	25	5	20
" 16	48 "	9 "	1	25	1	4

Table V.

Oats hulled and treated with Oil of Lemon

Date	Time in Oil of Lemon	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 15	1 hr.	1 day	1			
		3 days	3			
		4 "	2			
		5 "	2			
		7 "	1			
		8 "	2	25	11	44

Table V. - Continued.

Date	Time in Oil of Lemon	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent to Germ.
Oct. 15	2 hrs.	1 day	4			
		3 days	2			
		5 "	2			
		7 "	3			
		12 "	1	25	12	48
" 15	3 hrs.	5 "	14			
		6 "	10			
		12 "	1	25	25	100
" 20	4 "	3 "	18			
		4 "	1			
		7 "	1	25	20	80
" 21	24 "	2 "	9			
		3 "	3			
		4 "	1			
		6 "	2			
		8 "	1	25	16	64
" 22	48 "	2 "	8			
		3 "	2			
		5 "	3			
		7 "	1			
		8 "	2	25	16	64

The effect of turpentine and oil of camphor on corn was next considered. Grains of corn (White Champion Pearl) were immersed in turpentine for periods ranging from ten minutes to seventy-six days, the experiments being carried along two distinct lines. First, air dry grains were immersed in the turpentine for a given length of time, and second, grains soaked in water for periods varying from thirty minutes to one hour and thirty minutes were immersed in turpentine for periods similar to those not soaked in water. The air dry grains bore the immersion for a long period remarkably well (table Vl.); those soaked in water previous to the immersion in turpentine were very seriously injured. (Table Vll.)

Table Vl.

Grains treated with Turpentine.

Date	Time in Turpentine	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent. to Germ.
Dec. 8	Normal	3 days	8	10	10	100
		4 "	2			
" 8	10 min.	3 "	8	10	10	100
		4 "	1			
		5 "	1			
" 8	20 "	3 "	6	10	10	100
		4 "	4			
" 8	30 "	3 "	6	10	9	90
		4 "	2			
		5 "	1			
" 8	40 "	3 "	8	10	10	100
		4 "	2			
" 9	50 "	3 "	4	10	10	100
		4 "	6			
" 9	1 hr.	3 "	7	10	10	100
		4 "	3			
" 9	1 hr. & 10 min.	3 "	3	10	10	100
		4 "	5			
		5 "	1			
		6 "	1			
" 10	1 hr. & 20 min.	3 "	4	10	10	100
		4 "	6			
" 10	1 hr. & 30 min.	3 "	2	10	10	100
		4 "	8			
" 12	3 hrs.	3 "	8	10	10	100
		4 "	1			
		5 "	1			
" 12	4 hrs.	3 "	5	10	9	90
		4 "	3			
		5 "	1			
" 15	5 hrs.	3 "	5	10	10	100
		4 "	5			

Table Vl. - Continued.

Date	Time in Turpentine	Time required for Germination		No. of Seeds	Total No. to Germ.	Percent. to Germ.
Jan. 8	2 days	3 days 4 "	1 9	10	10	100
" 9	3 "	3 " 4 " 5 "	5 4 1	10	10	100
" 10	4 "	3 " 4 "	7 2	10	9	90
" 12	6 "	2 " 3 " 4 "	1 1 6	10	8	80
" 13	7 "	3 " 4 " 5 " 6 "	2 4 1 2	10	9	90
" 14	8 "	5 " 6 "	8 2	10	10	100
" 6	18 "	3 " 4 " 7 "	3 3 1	10	7	70
Feb. 12	55 "	7 " 8 "	4 1	10	5	50
Mar. 15	76 "	8 "	5	10	5	50

Table Vll.

Grain soaked in Water and then treated with Turpentine.

Date	Time in Turpentine	Time in Water	Time required for Germ.		No. of Seeds	Total No. to Germ.	Per Cent to Germ.
Dec. 8	10 min.	30 min.	3 days 5 " 7 "	7 1 1	10	9	90
" 8	20 "	30 "	3 " 4 " 5 " 7 "	6 2 1 1	10	10	100

Table VII. - Continued.

Date	Time in Turpentine	Time in Water	Time required for Germ.		No. of Seeds	total No. to Germ.	per cent to Germ.
Dec. 8	30 min.	30 min.	3 days	4			
			4 "	5			
			5 "	1	10	10	100
" 8	45 "	30 "	3 "	4			
			4 "	2			
			5 "	2			
			7 "	1	10	9	90
" 8	50 "	30 "	4 "	3			
			5 "	3			
			7 "	2			
			8 "	1	10	9	90
" 10	10 "	1 hr.	5 "	10	10	10	100
" 10	20 "	1 hr.	5 "	10	10	10	100
" 10	30 "	1 hr.	3 "	1			
			5 "	8			
			6 "	1	10	10	100
" 12	3 hrs.	1 "	3 "	4			
			4 "	3			
			7 "	1	10	8	80
" 12	4 "	1 "	3 "	3			
			5 "	1			
			6 "	2	10	6	60
" 15	5 "	1 "	4 "	1			
		30 min.	5 "	1	10	2	20
Jan. 8	2 days	1 hr. 30 min.	6 "	1	10	1	10
" 9	3 "	1 hr. 30 min.			10	0	0
" 6	18 "	1 hr. 30 min.			10	0	0

The effect of the turpentine on the grains first soaked in water was very evident at sight. After immersion in turpentine for a few days, the embryos of grains previously soaked had turned brown, while the embryos of air dry grains immersed for four and one half months appeared perfectly normal.

A series of experiments was carried on with oil of camphor in exactly the same way. It was found that the per cent of germination was much lower in the series treated with camphor than in the series treated with turpentine. (Tables Vl, Vll, Vlll, lX.)

Table Vlll.

Grains treated with Camphor.

Date	Time in Camphor	Time required for Germination		No. of seeds	Total No. to Germ.	Percent Germ
Jan. 14	4 hrs.	3 days	2			
		4 "	2			
		5 "	3			
		6 "	2			
		7 "	1	10	10	100
" 15	5 "	4 "	4			
		6 "	3			
		8 "	2	10	9	90
" 16	7 "	3 "	1			
		4 "	3			
		5 "	2			
		7 "	2			
		10 "	2	10	10	100
" 19	3 days	4 "	4			
		7 "	5	10	9	90
" 20	4 "	6 "	4			
		8 "	2	10	6	60
" 21	5 "	6 "	4			
		8 "	1	10	5	50
" 22	6 "	6 "	4	10	4	40
" 23	7 "	8 "	3	10	3	30

Table IX.

Grains soaked in water and then treated with Camphor.

Date	Time in Camphor	Time in Water	Time required for Germ.		No. of Seeds	No. to Germ.	Per cent to Germ.
Jan. 14	4 hrs.	1 hr.	6 days	1			
			7 "	1			
			8 "	2	10	4	40
" 15	5 "	1 "	5 "	2			
			6 "	1			
			8 "	1			
			9 "	1	10	5	50
" 16	7 "	1 "	7 "	1			
			10 "	2	10	3	30
" 19	3 days	1 "	10 "	1	10	1	10

The question now arises as to what causes the grains previously soaked in water to be more seriously affected by the turpentine and camphor than those not previously soaked. It is not due to the fact that the seed coats become more permeable to the oils by previous soaking in water, for in the case of the radish when the coats were ruptured before immersion in oil of lemon almost as great a per cent germinated as when they were not previously ruptured. Also when the hull of the oats was removed and the seed immersed in the oil of lemon a higher per cent germinated than when they were not hulled. It cannot be due to a chemical change for the turpentine and water do not chemically react.

In the course of these experiments it was repeatedly noted that the number germinating decreased as the moisture content of the medium in which the seeds were placed for germination increased. A series of experiments

testing the effect of soil moisture in germination was undertaken. Grains of corn were immersed in turpentine and camphor for periods ranging from seven to forty-eight days. These were then planted in soil of different moisture content. To obtain the soil moisture and maintain it, the method used by Mr. Whitten was followed. A sample of soil was dried in the oven at one hundred degrees Centigrade for two days and then weighed. The same sample was thoroughly saturated with water and weighed again. The difference in the weight of the dry soil and of the saturated soil was the amount of water it would retain. The difference between the weight of the dry soil and the normal soil was the amount of moisture in the normal soil. Consequently to obtain a given per cent of soil moisture it was necessary only to add a given weight of water to the normal soil to obtain any given per cent of saturation.

In the following are considered, first, the period of immersion in turpentine or camphor, and second, the per cent of saturation of the soil.

Table X.

Grains treated with Turpentine and germinated in the Soil.

Date	Time in Turpentine	Degree of Saturation of Soil	No. of Seeds	Total No. to Germ.	Per cent to Germ.
Mar. 20	None	35%	20	19	95
" 20	"	70%	20	20	100
Apr. 1	"	25%	20	15	75
Mar. 20	7 days	35%	20	11	55

Table X. - Continued.

Date	Time in Turpentine	Degree of Saturation of Soil	No. of Seeds	Total No. to Germ.	Per cent to Germ.
Mar. 20	7 days	70%	20	7	28
" 22	9 "	35%	20	10	50
" 22	9 "	70%	20	5	25
Apr. 18	16 "	35%	20	8	40
" 18	16 "	50%	20	6	30
" 27	25 "	35%	20	7	35
" 27	25 "	55%	20	5	25
" 1	33 "	25%	20	6	30
" 1	41 "	25%	20	5	25
" 4	36 "	43%	20	5	25
" 4	44 "	43%	20	4	20
" 15	47 "	35%	20	5	25
" 15	55 "	35%	20	5	25
" 15	55 "	70%	20	2	10

Seeds treated with Camphor and germinated in the Soil.

Date	Time in Camphor	Degree of Saturation of Soil	No. of Seeds	Total No. to Germ.	Per cent to Germ.
Mar. 20	7 days	35%	20	15	75
" 20	7 "	70%	20	10	50
" 22	9 "	35%	20	15	75
" 22	9 "	70%	20	9	45
Apr. 18	16 "	35%	20	13	52
" 18	16 "	50%	20	11	54

Date	Time in Camphor	Degree of Saturation of Soil	No. of Seeds	Total No. to Germ.	Per cent to Germ.
April 1	33	25%	20	7	28
" 4	36	43%	20	6	30
" 15	48	35%	20	3	15
" 15	48	70%	20	1	5

It was noted that in a number of instances of seeds previously immersed in camphor and germinated in the soil were abnormal. The shoot instead of growing upward as in the normal seedling, curled again and again before coming above the surface of the ground. This abnormal growth probably is due to a toughening of the tissue of the membranes by the camphor and the consequent difficulty on the part of the seedling to free itself.
It was found that of seeds immersed in oils for varying periods of time that the resistance was much greater in those germinated in soil that those previously soaked in water and germinated on plaster blocks; and that those immersed for long periods in oil germinated when planted in soil but failed to germinate on being soaked in water and placed on plaster blocks.

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